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Driving a Greener Future: Assessing the Impact of Electric Buses on Carbon Emissions in Islamabad

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Abstract

As cities around the globe make efforts to counter climate change, electric buses have come into focus as a green substitute for traditional public transport. The transport sector is among the biggest emitters of greenhouse gases, especially in metropolitan cities. The current research analyzes the effect of electric buses on greenhouse gas emissions using a comparative emissions approach, comparing electric buses with conventional diesel buses. This study includes information from Islamabad's public transport system, examining parameters like fuel consumption, emission rates and energy efficiency. The findings reveal that substituting diesel buses with electric ones greatly reduces carbon emissions, offering a cleaner and greener public transport option. Moreover, the findings indicate that electric buses can help enhance air quality and reduce reliance on fossil fuels. To facilitate the integration of electric buses into Islamabad's public transportation system, this research suggests a multi-pronged strategy comprising government incentives, public-private collaboration, investment in renewable energy technologies, and careful development of charging infrastructure. Additionally, this research provides a useful reference point for policymakers, transport regulators, and city planners who are attempting to develop sustainable transport options for developing cities.

Keywords: Electric buses, carbon emissions, sustainable transportation, Islamabad, environmental impact

Introduction

The primary source of atmospheric pollution is an international transport sector. However green transportation and electric buses play an important role in reduction of carbon emissions. Developing countries are just starting with it although number of electric buses are running in developed economies. Internationally it was studied that emission produces by road transportation creating the air pollution and also cause the global warming. The important participants of Green House Gas are carbon dioxide, methane and Nitrous Oxide. These three gases are emitting by

using of vehicles. However the use of electric buses can improve the air quality. But the handling system and power producing systems of both these buses are different. Conventional buses are running on diesel or gasoline and converting chemical energy in to mechanical energy. On the other side if we talk about electric buses. The electric buses transform the chemical Energy in to Electrical energy. There is a need of maintenance in conventional buses rather than Electric buses. Therefore Electric buses are Environmental friendly while conventional buses produces carbon emission and cause the climate change (Saleem.et.al, 2024). One of Brazil study accounts that the major share of these pollutants are come from fossil fuel vehicles such as truck and automobiles. Which are causing 40% and 31% of greenhouse gases. Therefore, reducing automobile emissions plays a critical role in reducing greenhouse gases and improving air quality. This requirement promotes the Automobile industry Technology evolution and Renewable energy development. In this sense, the adoption of Electric vehicles (EVs) is a good alternative that contributes to reducing (CO_2) emissions (Mao Feng, et.al,2021).European consider the biggest cause of environmental Degradation is the air pollution. It has bad impact on the health of people and it is also a cause of premature death of 400,000 people. The European Union set the Goal to reduce the carbon emission in 2030 by 40% and in 2040 by 60%. So to achieve this Goal there is a need of clean technology. The innovation of this clean technology is Hybrid mode BRTs. Therefore, these effort shift the fleet of buses in to electric buses which produces zero carbon emissions (Ribeiro .et al,2022). The advance in battery storage, Magnet and Renewable sources have reduced the carbon emission of the EV. The optimization of Electricity structure and increase in battery energy density and EV mileage can further reduce the life cycle environmental impact of the EV (Yu et al., 2018).BRT offer number of useful features like technologies and facilities to provide a people better travel experience because BRT is a modern public bus system. Travel information is very important for making the use of BRT easier and more attractive for passengers. But it is important that travel information should be Accurate. Passengers can take information through phones and by using internet. Therefore it is more important for travelers before start their journey they must know about their Route. They also know about current station, next stop and bus arrival time these all features will reduce their waited time. In this way we can make BRT system more efficient (Shah syed.et.al,2020)**.** Use of fuel by conventional transport produces a lot of carbon dioxide and air pollution which is not only damage the environment but also more costly. Pakistan should introduce the Electric vehicle in order to make a more efficient transport system. By adopting the use of EV it may reduce 20% of the emissions. Government has introduced the electric vehicle policy in 2019. At that time electric vehicle policy was not encouraging but now in 2025 most of the vehicles are converting on hybrid mode (Azhar .et.al, 2020). Large cities are facing transportation problems. Karachi is a big city of Pakistan and there is also a transportation problem in Karachi. Due to the deficiency of better policies the condition of an urban areas is going to destroy day by day. Public transport system just focus on their profit maximization .in this way they cannot provide convenient services to the passengers due to this people try to use private cars

or Purchasing bikes for their travelling purposes. By use of private vehicles there would be traffic congestion on the roads. From 2013 – 2017 the number of registered motor bikes were 50%. Public transport are decreasing very fast. A lot of models has been introduced by making low use of fuel cars and increasing energy efficient technologies such as Electric vehicles (Noman.et.al, 2020). Pakistan, India, south Asia and Sirilanka are highly rely on oil based transportation system. These countries are developing countries with most populated area. Their dependency on fuel based vehicles destroy their balance of payment and also increasing the carbon emissions. In 2018 Pakistan was using more than 75 .5 % of petrol in transport (Shahid et.al, 2022). According to the report Global Atmosphere Watch (GAW) there is a harmful impact on human health through the fuel combustion. As well as carbon emissions are increasing the air quality become more polluted. So instead of using conventional diesel powered buses the best alternative is to use sustainable environmental friendly buses such as electric buses **(**Majumder.et.al, 2021). Therefore governments have taken some steps to convert diesel buses with sustainable energy buses to minimize greenhouse gas emissions.so instead of using different fuels for BRT its much better to switching in to sustainable energy buses which minimize the Green House GAS emissions**.** The innovation of lithium-ion battery (LIB) technology has turned electric vehicles into a renewable mobility alternative over the last decade that requires minimal maintenance. Some studies conclude that (LIB) technology is still developing, and the reliability, specific energy, and quality of such technology could be still enhanced over time (Abbasi.et.al, 2022).Pakistan, among other countries, has published a National Electric Vehicle Policy (NEVP) to shift to 50% of new buses sales by 2030 and 90% by 2090 which will significantly reduce the tailpipe emissions from transportation. To mitigate the carbon footprints from the energy mix, Pakistan is shifting to a Greener energy resource. Pakistan has adopted an Alternate and Renewable Energy (ARE) policy to go 60% green by 2030. Currently, Pakistan produces 42% Green Energy , and by 2030 NEPRA Forecasts this to be 75% Green Energy which will result in 42.5% fewer carbon emissions from our energy mix, reducing from 0.416 Kg/kWh to 0.239 Kg/kWh. Given the forecast, Pakistan is expected to reach its goals within the timeline. This study includes information from Islamabad's public transport system, examining parameters like fuel consumption, emission rates and energy efficiency. The findings reveal that substituting diesel buses with electric ones greatly reduces carbon emissions, offering a cleaner and Greener public transport option. Moreover, the findings indicate that Electric buses can help to enhance air quality and reduce the reliance on fossil fuels.

Materials and Methods

The data used in that study collected from the CDA office, from route operation logs, bus specification and government transportation reports. Key variables included are the following. Forward and backward route distances, Number of buses per route, Daily trips per bus, Total route distance per day, Fuel efficiency (km per liter for diesel, km per kWh for electric), Emission factors (2.68 kg CO_2/liter for diesel, 0.359 kg CO_2/kWh for electric based on Pakistan’s grid). Tank to wheel (TTW) approach is used in this case study. This model analyses the energy used and

emissions generated by a vehicles from where fuel is delivered to the vehicles (the tank) up until it's consumed, on the wheels. This is an index about the performance of vehicle powertrain energy transformation, this test pay attention to that how much final use fuel car get and what path they become. The current study uses a scenario analysis methodology to compute carbon dioxide (CO_2) emissions from diesel and electric buses operating in Islamabad. The analysis uses authentic operational data from BRT (Bus Rapid Transit) routes, comprising the Red Line and Orange Line as well as fifteen fully electric bus routes. Emission reductions can be examined under 3 fleet composition scenarios: 100% diesel, 50% electric and 50%diesel (without emission zone), or with a cleaner option such as EV just to judge if E-Energy acts badly for other emissions. The methodology includes Calculating total daily distance per route, Estimating fuel or energy use using known efficiency figures, Applying emission factors to derive total (CO_2) emissions, Running scenario simulations for full diesel, mixed, and full electric fleets. The following formula is using to calculate emissions which are created by diesel/batteries.

Diesel: Emissions= Distance/ km per litre*2.68

Electric: Emissions= Distance/km/kwh*0.359

Route Type	***Daily Distance (km)***	***Efficiency***	***Energy/Fuel Used***	***Emission Factor***	***Emissions (kg (co_2) /day***
Red Line (Diesel)	15,232	1.6km/l	15,232/1.6=9,520 L	2.68kg/l	9,520(2.68)= 25,513.6
Orange Line (Diesel)	12,487.2	2.8km/l	12,487.2/2.8= 4,459L	2.68kg/l	4,459(2.68)= 11,947.5
Red Line (Electric)	15,232	1.97 Km/kwh	15,232/1.97=7,729.44Kwh	0.359kg/kwh	7,729.44(0.359)=2,774.87
Orange Line (Electric)	12,487.2	1.97 Km/kwh	12,487.2/1.97=6,339.19Kwh	0.359kg/kwh	6,339.19(0.359)=2,274.76
EV Routes (Electric)	-	1.97 km/kwh	0.359 kg/kwh	0.359kg/kwh	Provided total = 68,309.64

Scenario A: If 100% diesel fleet

Red line (diesel) 25,513.6kg (CO_2)

Orange line (diesel) 11,974.5kg (CO_2)

EV Routes (assumed converted to diesel) 68,309.64 kg (CO_2) (hypothetical)

Total Emission= Red Line (Diesel) + Orange Line (Diesel) +Ev Routes (Electric)

Total Emission = 25,513.6+11,974.5 +68, 309.64 = 105,770.74 kg(CO_2) /day

Scenario B: If 50% diesel and 50% Electric fleet

If Orange line and Red line BRT are running 50% on diesel and 50% on electric fleet then we can calculate as. For example if first of calculated Red line.

Red line (Diesel):

(25,513.6)(0.5) = 12,756.8kg Red line
(Electric):

(2,774.87)(0.5) = 1,387.44kg

If we sum up both of them then total emissions will come from red line BRT either on Diesel or on Electric.

Total = 12,756.8kg + 1,387.44kg = 14,144.24kg

Orange line (Diesel):

11,947.5 (0.5) = 5,973.75kg

Orange line (electric):

2,274.76 (0.5) = 1,137.38kg

Total = diesel +electric

5,973.75 + 1,137.38 = 7,111.13kg

EV Routes = 68,309.64 kg

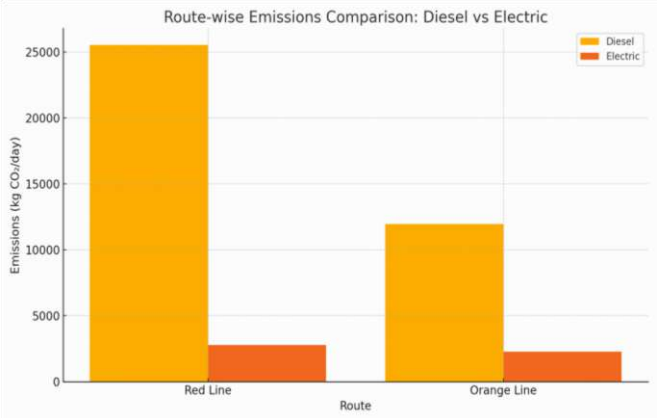
Total = 14,144.24+7,111.13+68,309.64

= 89,564 .99kg/day

Scenario C: If all BRT Orange Line Red line are on Electric fleet:

= 2,774.87+ 2,274.76+ 68,309.64 = 73,359.27 kg co2/day

Route-wise Emissions Comparison: Diesel vs. Electric:



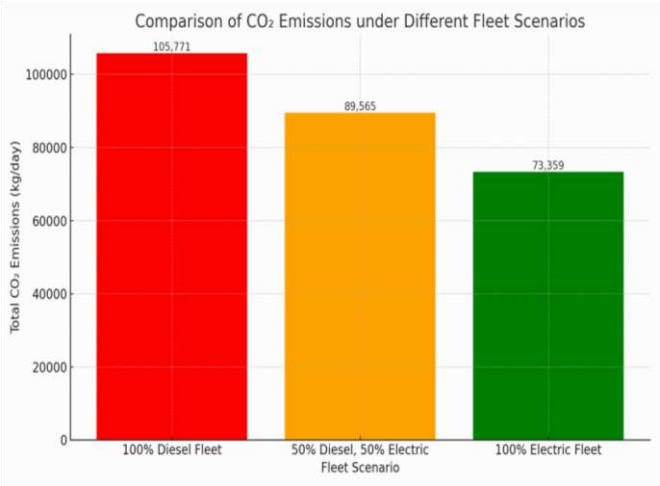
This graph contrasts (CO_2) pollution from diesel and electric buses on two primary routes. Red Line Diesel buses emit 25,514 kg/day of CO_2. Electric buses emit just 2,775 kg/day. Orange Line Diesel buses emit 11,948 kg/day. Electric buses emit only 2,275 kg/day. Both routes indicate an enormous reduction in emissions when electric buses replace diesel. For instance, emissions on the Red Line decrease by nearly 90% when using electric.

Comparison of Emissions:

Scenario	**Total(CO_2) (Emissions(kg/day)**	**Reduction vs Diesel(%)**
100 % diesel Fleet	105,770.74	-
50 % diesel,50% electric fleet	89,564.99	15.33%
100% Electric Fleet	73,359.27	30.64%

Fleet Scenario Emissions:

This bar graph demonstrates the total quantity of carbon dioxide (CO_2) emissions generated on a daily basis under three scenarios of public transport fleets in Islamabad. Present scenario where all buses are diesel-powered. It generates the maximum emissions approximately 105,771 kg of (CO_2) per day.50% Diesel, 50% Electric Fleet: Here, the buses are half diesel and half electric. The emissions are reduced to around 89,565 kg/day, which is a 15.33% decrease in pollution. If the buses are fully electric, emissions are reduced even further to 73,359 kg/day, a 30.64% decrease from the 100% diesel fleet.



Results and Discussion

The current study deploy Tank to wheel (TTW) model for compare the carbon dioxide emissions from Diesel mode BRTs and Electric vehicles which are running on Batteries**.** Through analysis we have obtain results from the data of BRTs Red line , orange line and Ev vehicles which are running in Islamabad the capital city of Pakistan . According to the results we conclude that when BRT are running on Diesel in this way they are producing more carbon emissions such 105,770.74 and destroy the environment.in other side those Vehicles which are running on 50% diesel and 50% on electric batteries are producing less carbon emissions i.e. . 89,564.99 And if Vehicles are 100 % on electric mode then (CO_2) (Emissions (kg/day) are 73,359.27. more quantity of fuel releases a big amount of carbon dioxide in to environment when BRTs are tracking on diesel. however everyday carbon dioxide emission from red line emits 25,514kg. The orange line release about 11,948 kg per day. Although the amount of carbon emission reduces when EV are running even on the same routes 68,310 kg emits from EV. 80% pollution decreases by red and orange line buses through moving from fuel to batteries. A few amount of emissions also generating by EV but these emissions are less harmful as compared to diesel buses. Out of this 105,770.74kg of (CO_2) are emitted per day in a completely diesel-operated fleet .This scenario reflects the business-as-usual high-impact

baseline and is influenced by fossil fuel combustion in conventional diesel buses. If Red and orange line buses are converting 50% hybrid and 50% diesel then at that time 89,564.99 kg/day emissions drop. the results shows that 15.33% (CO_2) can be decreases by switching on batteries as compared to the scenario which shows that 100 % fuel consumed by BRTs. 73,359.27kg/day (CO_2) will be decrease when red and orange line BRTs switching 100% on electric system.(Drier et.al ,2018) conducted a research on BRT system in Curitiba using a (TTW) approach for many bus powertrains systems. According to him (GHG) can be reduces by the use of EV as compared to conventional bus system. Transitioning from diesel to electric buses not only reduces CO_2 emissions substantially but also supports Pakistan's broader commitments to sustainable development and cleaner urban transport. A phased transition starting with a 50/50 fleet and moving toward full electrification offers a realistic and impactful roadmap. This study clearly shows that if we replace diesel buses with electric ones in Islamabad, especially on major routes like the Red and Orange Lines, we can greatly reduce air pollution and help the environment. It's a strong argument for investing more in electric public transport.

Conclusion

In this research, the carbon emissions of diesel and electric buses running on Islamabad's Bus Rapid Transit (BRT) corridors were thoroughly assessed through a Tank-to-Wheel (TTW) analysis. The results strictly show that the shift from traditional diesel buses to electric vehicles (EVs) can bring down urban transport greenhouse gas emissions substantially. Under the 100% diesel fleet option, daily emissions averaged about 105,770.74 kg of CO_2, underscoring the environmental cost of fossil fuel transport. A 50% diesel, 50% electric fleet had its emissions cut to 89,564.99 kg/day, a 15.33% decrease. The best result came in the form of the 100% electric fleet option that cut emissions to 73,359.27 kg/day, a 30.64% CO_2 output decrease from the baseline. These findings highlight the beneficial environmental effect of Electrifying public transportation systems. Although Electric buses do emit some emissions predominantly attributed to the energy mix of the national grid they are significantly cleaner than their diesel equivalents. Additionally, when run on Renewable power sources, their environmental impact can be further reduced. The research finds that adopting electric buses particularly for busy routes like Islamabad's Red and Orange Lines not only helps to curb climate change but also enhances urban air quality, promotes sustainable development goals (SDGs), and is consistent with Pakistan's National Electric Vehicle Policy (NEVP) and Alternate and Renewable Energy Policy. A phased fleet transition plan is both feasible and effective, and it presents a plausible route to greener, healthier, and more sustainable cities. According to the assessment of TTW emissions and scenario simulations, some policy recommendations are outlined here. Focus on Electrifying High-Mileage Routes the biggest bang for the buck comes from converting diesel buses in high-use corridors, such as the Red and Orange Lines to electric first. Introduce Phased Electrification Requirements,

Introduce milestones like 30% fleet electrification by 2027 and 60% for the year of up to which these targets are prescribed as per NEVP (National Electric Vehicle Policy) standards. Charging infrastructure has to be improved. Deploy fast-charging depots at key bus termini and along EV lanes to maintain serviceability and system agility. Incentivizes Public Transport Authorities Provide financial inducements in the form of carbon credits or subsidies for those agencies taking up electric fleets and meeting their emission reduction targets. Monitoring and Reporting Emissions Deploy pattern-level tracking of emissions for institutionalized evidence-based planning and progress reporting just like an open line. Pair Electrification with Clean Energy. Further reduce the carbon intensity of mobility by asking charging stations to buy electricity from solar or wind power (on when possible). If these policy measures are adopted, Islamabad and other urban centers in Pakistan will be able to transition faster towards sustainable urban mobility leading to an SDG 7 aligned transport sector while contributing sufficiently towards climate goals as well as work toward cleaner air quality for millions of people living within those cities.

Limitations and Future Work:

Present study use Tank to Wheel model and measure the carbon Emissions which are creating by Diesel and Hybrid mode BRT in Islamabad. However we didn't interview passengers or drivers and ask them what they feel about Electric buses. Their satisfaction and opinions also matter for success. We researched only the pollution emitted during bus usage, not the pollution generated in producing or recycling electric bus batteries. We can apply maps and computer simulations to identify the best locations in Islamabad to construct charging points for electric buses. This will be easier and quicker to charge. With the help of new Technology such as AI (artificial intelligence) and GIS maps. We can research how to recycle spent batteries from Electric buses safely in Islamabad. This can save waste and Generate jobs.

References

[1] Abbasi, M.,and Hadji Hosseinlou, M. Assessing feasibility of overnight-charging electric bus in a real-world BRT system in the context of a developing country. Scientia Iranica, *29*(6), 2968-2978, (2022).

[2] Dreier, D., Silveira, S., Khatiwada, D., Fonseca, K. V., Nieweglowski, R., and Schepanski, R. Well-to-Wheel analysis of fossil energy use and greenhouse gas emissions for conventional, hybrid-electric and plug-in hybrid-electric city buses in the BRT system in Curitiba, Brazil. Transportation research Part D: transport and environment, *58*, 122-138, (2018).

[3] Majumder, S., De, K., Kumar, P., Sengupta, B., and Biswas, P. K. Techno-commercial analysis of sustainable E-bus-based public transit systems: An Indian case study. *Renewable and Sustainable Energy Reviews*, *144*, 111033 and (2021).

[4] Mao, F., Li, Z., and Zhang, K. A comparison of carbon dioxide emissions between battery electric buses and conventional diesel buses. Sustainability, *13*(9), 5170, (2021).

[5] Noman, S. M., Ahmed, A., and Ali, M. S. Comparative analysis of public transport modes available in Karachi, Pakistan. SN Applied Sciences, *2*, 1-13, (2020).

[6] Ribeiro, P. J., and Mendes, J. F. Towards zero CO2 emissions from public transport: The pathway to the decarbonization of the Portuguese urban bus fleet. *Sustainability*, *14*(15), 9111, (2022).

[7] Saleem, M. H., Ali, S. W., and Shehzad, S. A. Emission Reduction in Urban Environments by Replacing Conventional City Buses with Electric Bus Technology: A Case Study of Pakistan. arXiv preprint arXiv:*2407.20139*. (2024).

[8] Shah, S. A. R., Shahzad, M., Ahmad, N., Zamad, A., Hussan, S., Aslam, M. A., ... and Waseem, M. Performance evaluation of bus rapid transit system: A comparative analysis of alternative approaches for energy efficient eco-friendly public transport system. Energies, *13*(6), 1377,(2020).

[9] Shahid, M., Ullah, K., Imran, K., Masroor, N., and Sajid, M. B. Economic and environmental analysis of green transport penetration in Pakistan. Energy Policy, *166*, 113040,(2022).

[10] Ul-Haq, A., Jalal, M., Hassan, M. S., Sindi, H. F., Shah, A., and Anjum, A. .Electric transportation in pakistan under CPEC project: Technical framework and policy implications.

IEEe Access, *8*, 162394-162420, (2020).

[11] Yu, A., Wei, Y., Chen, W., Peng, N., and Peng, L. Life cycle environmental impacts and carbon emissions: A case study of electric and gasoline vehicles in China. Transportation Research Part D: Transport and Environment, *65*, 409-420,(2018).